SCIENCE

VOL. 93 FRIDAY, JUNE 20, 1941 No. 2425

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

SCIENCE, NATIONAL AND INTERNATIONAL, AND THE BASIS OF COOPERATION[1]

By Dr. A. V. HILL, M.P.

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I SHOULD be the last to claim that we scientific men, as a class, are less liable to prejudice on grounds of self-interest, race, politics or religion than other educated people; and we should deceive ourselves, and perhaps some uncritical members of the public, if we were to assume (as some of us seem to do) that scientific eminence, or the scientific habit of mind, as such, or even scientific notoriety, give any special virtue to our opinions on more ordinary topics. It is, nevertheless, a fact that the nature of our occupation makes scientific men particularly international in their outlook. In its judgments on facts science claims to be independent of political opinion, of nationality, of material profit. It believes that nature will give a single answer to any question properly framed, and that only one picture can ultimately be put together from the very complex jigsaw puzzle which the world presents. Individual and national bias, fashion, material advantage, a temporary emergency, may determine which part of the puzzle at any moment is subject to the greatest activity. For its final judgments, however, for its estimates of scientific validity, there is a single court of appeal in nature itself, and nobody disputes its jurisdiction. Those who talk, for example, of Aryan and non-Aryan physics or of proletarian and capitalist genetics, as though they were different, simply make themselves ridiculous. For such reasons the community of scientific people throughout the world is convinced of the necessity of international collaboration;

[1] Read at the Annual General Meeting of the Parliamentary and Scientific Committee held in the House of Commons.

has practiced such collaboration for many years, indeed along the centuries; and has built up an elaborate system of congresses and unions of standards, units and nomenclature, and of abstracting journals, together with a wide-spread interchange of research workers and ideas from one country to another.

In no other form of human activity, therefore, has so complete an internationalism spread throughout the national structure of society: in no other profession or craft is there so general an understanding or appreciation of fellow workers in other parts of the world. This implies no special merit or broadmindedness on the part of scientific men; it is their very good fortune, a good fortune which involves obligations as well as privileges. For example, when the Nazis in 1933 began their persecution of Jews and liberals in Germany, it was the scientific community in many other countries which came most quickly to the rescue of their colleagues: not out of any special generosity but because *firstly* they had personal knowledge of those who were being persecuted, and *secondly* they realized that such persecution struck at the basis of the position of science and scientific workers in society. Again, in the treatment of aliens in this country during the present war, the scientific community more than any other, and quite regardless of political complexion, has stood for a liberal and reasonable policy: desiring both to maintain the high tradition which the world of learning has inherited from the past and also to make use of the willing help of people whom it knew personally to be loyal to the cause of freedom for which we are fighting. Again, in the United States to-day there is no section of the public so unanimously concerned for the victory of British arms as the community of university and particularly of scientific people. These realize that the basis of all progress in science and learning is international cooperation, and they can not conceive how such cooperation could be possible under a Nazi domination of the world.

It may well be, then, that through this by-product of international cooperation science may do as great a service to society (just as learning did in the Middle Ages) as by any direct results in improving knowledge and controlling natural forces: not—as I would emphasize again—from any special virtue which we scientists have, but because in science world society can see a model of international coperation carried on *not merely for idealistic reasons, but because it is the obvious and necessary basis of any system that is to work.*

One of the great tasks lying before scientific people after the present war will be to rebuild, and to rebuild on a firmer and better foundation, the international scientific organizations which have come into being in the last 70 years, particularly during the present century. The earliest of these was the International Bureau of Weights and Measures, established in 1873. An International Geodetic Association followed, and in 1903 an International Seismological Association on the same lines. Arising from the initiative in 1898 of the Academies of Munich and Vienna, together with the Royal Societies of Gottingen and Leipzig, which had all been in the habit of meeting annually, the Royal Society (of London) undertook to approach a number of foreign academies with a view to the formation of an international association of academies. As an independent institution, not subject to state control as were so many of the academies, the Royal Society was in a very favorable position for opening such negotiations. As a result the International Association of Academies was formed, which held five meetings in all, the sixth at St. Petersburg being cancelled owing to the outbreak of war in 1914. It never met again.

These meetings were not limited to natural science, many of the academies being concerned both with the scientific and the humanistic side of learning. It is interesting that as one result of this movement, and in order to represent Great Britain on the literary philosophical and historical sides, the British Academy was formed and incorporated by Royal Charter in 1902. We of the Royal Society have always hoped that the British Academy will ultimately take the same place in national life in respect of humanistic studies as the Royal Society has long had in respect of "natural knowledge." There is need for such independent bodies of high standing and disinterested outlook, particularly when so many functions are being taken over, often quite suddenly and without any one noticing, by the state. The Royal Society, in spite of its independence, has always, since its foundation in 1662, had close relations with the Government, and it would take a small book to recount the many occasions on which its advice has been asked. It has recently been given still another privilege and duty, under the Lord President, in advising the War Cabinet on scientific matters through its president and secretaries, who are members of the Scientific Advisory Committee. One hopes that in some form or other, this function, no less necessary in peacetime, will continue after the war. *Could not a similar provision be usefully made now for those complementary studies which the British Academy represents?* This is an interpolation, not strictly relevant to the thesis of this address, but I feel it is of some importance. The reconstruction of Britain and of our international relationships, in learning and the arts of peace, as well as in social and economic directions, is a matter of great concern about which we should be thinking already. In so doing, a disinterested body of high standing such as the British Academy is, with no particular political axe to grind, might render the greatest possible service to the state. Science will have

a special part to play, now and in the future, in national and international affairs, and it is right that independent science should have access to the chief center of government. Other branches, however, of disinterested learning, have an equal if different application, and one would like to see for them a similar machinery created. Science is at last coming into its own in relation to social, national and international affairs. The older branches of learning, too long contemptuous, have begun to realize the situation: but that need not mean that social, historical, economic, literary and philosophical studies will have their influence diminished; only that the influence of learning as a whole will be increased.

To return to my story. Just before the end of the last war, in 1918, representatives of the academies of all the allied countries met in London, and later in Paris, to discuss the formation of a new international scientific organization. In July, 1919, the first General Assembly of the International Research Council, as it was to be called, met in Brussels. Representatives of the Central Powers were not invited, and a misunderstanding which then arose was made an excuse for declining an invitation which was sent to each of them a few years later. This unfortunate state of affairs persisted. German professors who feel themselves insulted are difficult people to appease, and indeed the fault was not all on their side. International Unions for Astronomy, Geodesy and Geophysics, Chemistry and Mathematics (this last no longer in existence) were formed; and at the next General Assembly in 1922, for Physics, Scientific Radio, Geography and Biology. Some of these unions have functioned well and have held important international congresses and done important work; others have done little. The ones that have worked best, *e.g.*, Scientific Radio, are those which had a more practical international task to fulfil.

These unions always had an official or semi-official flavor: official delegates, official hospitality, official finance, official business, have tended to put independent science into a somewhat subordinate position. Physiologists have held international congresses for fifty years, and great value these have had, as we know, who have taken part in them: but physiologists have always insisted that they came as independent scientists, to meet, to hear and to discuss things with their colleagues; not as representatives of some state institution or interest. Other scientific groups have held similar informal congresses based on the same idea. There is grave danger, as was found by the Physiological Congress meeting in Italy in 1932, and in the Soviet Union in 1935, of a congress being used as an opportunity for political propaganda: in 1938 this was altogether avoided by the tact and understanding of Swiss colleagues, as it had been avoided at meetings prior to 1932. Political considerations are hard enough to avoid anyhow, but they are much worse if a congress is not genuinely independent.

In this country and in America, the great strength and the high position of the independent scientific societies make it easy for them to take charge of the proceedings of a congress, or of an inquiry of international importance, without danger of state control —either in appearance or reality. But this is not so easy, indeed it has been impossible in recent years, in many countries. In order to preserve the integrity of science in our own country, it is very important that those strong independent scientific bodies should be maintained: and for the sake of international scientific relations it is desirable that in other countries also, so far as we can influence them, the domination of the state over science should be tempered by public appreciation of the part played by independent scientific agencies and institutions

In some form or other, not, one may hope, exactly in their present form, these international unions must be started up again some day. This time, at any rate, we shall not be prevented from following our better judgment by the intransigence of French colleagues: though it may be hard enough for us this time to take a detached view. My own feeling is that in this matter we should rely, as far as possible, upon the help and advice of our American scientific friends. Their views about science, for its own sake and in relation to the state, are much the same as ours, and they (at present at least) are further from the battle. I know they would regard it as a sacred trust of friendship to bear a large part of the burden of starting off again the international cooperation in scientific endeavor which was so unhappily ended by the events of the last years.

In America, as in Britain, science is largely independent of the state. There, as here, great scientific organizations work under government auspices; there, far more than here, the great corporations maintain their research departments; there, as here, free universities and free endowments are engaged in promoting the advance of scientific knowledge; there, as here, free and independent science is able to cooperate with the scientific agencies of government and industry, to the great advantage of all. There is a high idealism in America about international cooperation in the field of science and learning, and a very great regard for British science and British scientists. If the war goes ultimately as we expect, in the downfall of dictatorship and tyranny, it will be our job to start off again, on broader and better lines, the complex system of international scientific cooperation: and in starting it off I am sure that we shall be able to call

for the help and coperation without stint or limit, of our scientific friends in America.

I have spoken several times of the necessity of guarding the independence, the spiritual integrity of science. In many countries to-day science is wholly subservient to the state: its soul is not its own. I do not deny for a moment the importance, indeed the necessity, of scientific organizations within the framework of government, or of liberal support by the state of scientific research. One can only welcome such recognition by the public of the importance of scientific knowledge and scientific discovery—and ask for more. There are several things, however, which one may fear. *Firstly,* the condition of stagnation and complacency which tends to develop in any scientific department or establishment which is cut off from outside criticism or ideas: we have far too many examples of this already, formidable examples, and if we are not careful they will multiply; the reduction of science to official routine can be a real menace. *Secondly,* the danger that science will be planned by administrators in offices instead of by young men with their sleeves rolled up, in laboratories or workshops. *Thirdly,* the disadvantage of separating teaching from research, to the great loss of the next generation who may miss the inspiration of seeing discovery going on in the places where they are taught. *Fourthly,* a decrease in the influence and prestige of those independent scientific bodies which play so large a part in the social and intellectual activities of the scientific community and provide the cross-connections between groups which might otherwise be isolated. *Fifthly,* the danger that he who pays the piper may call the tune, and that research may be required to be devoted primarily to objects which the politician, or the civil servant, regard for the moment as of national importance; or even—as in Germany and the Soviet Union —to bolstering up theories which the official philosophy of the state prescribes.

To avoid all these troubles, the independence and integrity of science must be carefully preserved; in the universities, in the learned societies, in the various associations or institutions devoted to the advancement of knowledge. Whenever state support is given, a buffer should be interposed, similar to that provided by the University Grants Committee between the universities and the treasury. In our existing research councils (Department of Scientific and Industrial Research, Medical Research Council and Agricultural Research Council), working with government funds, the buffer is already provided by the fact that the members of the councils are chiefly independent scientific men. The same safeguard exists at present with much of our state-aided research: we must carefully watch that the strength of this safeguard is fully maintained, that it does not become a formality, and that the principle is consciously extended wherever possible as the financial burden of scientific research and development is taken over (as is bound to happen more and more) by the state.

In many of the departments of government, however, notably those of the defense services, scientific research is undertaken on a grand scale, which can not be controlled directly by outside independent bodies. In these establishments particularly, the danger of stagnation and complacency exists. They are devoted to specific service purposes, often, of necessity, secret: and the condition of secrecy prevents them, in ordinary times, from attracting many of the ablest and brightest minds, who prefer the freer atmosphere of the universities, the possibility of discussing and publishing their results, and the recognition of their colleagues resulting therefrom. Consequently, in war, those who direct these establishments are often people who have arrived at their positions by seniority and long service, during which they have been largely isolated from the ideas and criticism of current scientific thought: it has been difficult for them not to become officials rather than working scientists. When an emergency occurs, as at present, numbers of able men come in, but to posts in which they can exert relatively little influence, and their ability and imagination may for long be imperfectly used. This indeed is inevitable under the present system, for they have at first no experience of service conditions and needs. After a year or two, perhaps, longer than necessary, these able people find their proper level, but not until much damage has been done by lack of imagination and energy in the posts they might have filled before.

To avoid this trouble—and it is a very real one—two main principles may be applied. *Firstly,* to introduce into each department or organization some kind of scientific advisory council, similar to that which on the whole works so well now in the Ministry of Supply. This council should consist partly of independent scientific men chosen for their special knowledge on the one hand, for their wide contact with the scientific community on the other: and partly of official scientific people representing not only the department or organization itself, but a variety of other departments, so that a good cross-section of official knowledge and experience is available. And *secondly,* in ordinary times to arrange for regular interchange of personnel between the government research establishments and organizations, and the universities and other independent institutions in which research is carried on.

I know that this second proposal will shock some of

those who have lived in the traditional secrecy of service science; but it is right all the same. Why should not a chemist or mathematician from Woolwich, a physicist from Signal School, an engineer from the Royal Aircraft Establishment, go back as a lecturer or professor to a university, or to the research staff in a commercial laboratory; just as a physiologist from the National Institution for Medical Research or an aeronautical engineer at the National Physical Laboratory or a zoologist at the Marine Biological Laboratory at Plymouth may do? And why should not the research workers in government laboratories be just as regular attendants at the meetings of scientific societies as those in other institutions? I sometimes thought, before the war, how good it would be to take a mission, harmonium and all, to one of the most important—and the most dead-alive—of these places and try to stir up a little general scientific enthusiasm.

It is difficult to get over vested interest and tradition in these things. As regards the first desideratum, that of an idependent scientific advisory council with the framework of a government organization, from a department where it does not exist already we are apt to get the reply from the political head or the permanent secretary, "When we want scientific advice we can always go to Sir X.Y.," not realizing that Sir X. has sat in an office for years and that, anyhow, he can not be knowledgeable on everything. Or we are told that the department has an excellent scientific organization of its own, which has, in fact, gone on without any expert criticism for many years, saved indeed from criticism by its well-preserved secrecy. Or it is said, "When we want scientific help we can turn to the D.S.I.R., the M.R.C. or the A.R.C., as the case may be." Those excellent bodies can in fact do much, but they can not do more for other departments than answer specific questions. A large part of scientific work lies in formulating the questions to be asked, and that can not be done except by people who are in close personal touch with the actual needs. A family doctor, in fact, is wanted, to watch over the scientific health of the department; to call in a consultant alone at intervals is little use; the family doctor must be available to realize the need and to understand the situation of the patient—*then* the consultant's advice is valuable. The three research councils are to be regarded as consultants, excellent and essential ones; but they do not make it unnecessary to have independent advice within a department.

As regards the second desideratum, that of a free interchange of personnel, backwards and forwards between government establishments and the universities and other outside scientific institutions, the first need is for a common pension scheme. All scientific workers, whether in the universities, or in commercial laboratories, or in government employment, should come under the Federated Superannuation System for Universities (F.S.S.U.) as do those employed by the three Research Councils (D.S.I.R., M.R.C., A.R.C.). Then the departments should insist on sending their people away at intervals, to carry on research elsewhere and to refresh their souls in institutions outside. Conversely, the departments should invite outside scientists (naturally under proper safeguards of secrecy when necessary) to work for corresponding periods in their establishments. The advantage of this second step would be that the importance and interest of the problems which are being tackled in government establishments would be more commonly realized, and better men would be inclined to take part in their solution. In the defense services a reserve of officers and other ranks is an essential part of an efficient organization for war: in the scientific services similarly, a reserve of research workers for the case of emergency of any kind, would seem to be equally essential. I am not thinking only of war; other emergencies occur requiring the sudden application of scientific knowledge and method. It would be simple and not very expensive to build up such a reserve of scientific talent, available for service when needed and in so doing to introduce a new spirit and a new outlook into government scientific establishments.

One great advantage of working in the scientific establishments either of the government or of a large company or corporation, is the fact that equipment is not limited below the minimum that is necessary for efficiency. In most of the free institutions, money for research is notoriously short. One of the great needs of research is better financial support, and in the relative poverty of charitable people and bodies to which I fear we must look forward for some time, this support will have to come from the state. One hears proposals made, for example, for a national research council to be set up to administer grants for research. In considering such proposals we should be wise to remember three principles:

(*a*) that a powerful buffer is required to prevent the state from interfering with the integrity and independence of research, and to save research from being over-planned and directed by officials sitting in government offices;

(*b*) that it is often better to ask existing and experienced agencies, which we know to work, to undertake new jobs, in spite perhaps of apparent imperfections in their organization, rather than to allow our young revolutionaries to scrap the old and set up new schemes, cleaner on paper but untried;

(*c*) that the chief value of research grants will often be to young and comparatively unknown people, so that as far as possible devolution of allocation should be adopted, and the responsibility left to the university or other institution in which they work and where they are known.

For my part, as regards research in the universities, I should feel inclined, if a government fund of, say, one million pounds were available for scientific research, to ask the University Grants Committee to allocate it to different universities as they do the larger sum of two and a quarter million pounds of the Treasury grant. Each university would then deal with the disposal of the sum allotted to it, in much the same way as the Royal Society does with the Government Grant for Scientific Investigations; and as in the last few years the University of London has already done with a substantial fund which it has put aside for this very purpose from its own resources. It is true that, of the Treasury Grant of two and a quarter million allotted by the University Grants Committee, a considerable part goes ultimately to research; or at least to maintaining the people and the institutions by whom and in which research is done. I know, however, from long experience, both personally and by helping to administer the Royal Society grant, the great advantage to the individual and to the institution where he works, of the possibility of obtaining a grant, possibly large, more often small, for a specific research project; to be expended by the young research worker (or the older one) at his discretion and not merely by the department. What the University of London has made a start in doing in this way, following on the example of the Government Grant for Scientific Investigation, administered by the Royal Society, can be done by other bodies; but money will be required. In the days of straitened circumstances which we can not but foresee ahead, it must come from the state if scientific investigation is to be kept up—as it must be; and the natural body to allocate it to its different claimants among the universities would be the University Grants Committee. In this way we could avoid creating new and untried machinery.

For research in industry, in medicine and in agriculture (apart from their overlap with university institutions) the machinery for similar grants exists already in the three Research Councils: with extended financial provision from the Treasury if necessary. In industry at least part of the sum required should be subscribed by the industry itself as it is at present with the Research Associations devoted to various subjects and working in cooperation with the D.S.I.R. The personal grants given at present by the D.S.I.R. for researches "of particular timeliness and promise" are of great value and could with advantage be extended.

I have tried to cover a large field in a very short time, and have been forced to deal for the most part with principles rather than details. I have omitted all reference to the pay and status of scientific people; the people themselves and the conditions vary widely, and for some men too much security just as well as too little may diminish their usefulness and initiative. I have not referred to the question of grants for students training for research, or of provision for weeding out those who show no scientific capacity; nor have I even mentioned scientific education, which would require a lecture to itself. And, lastly, I have not ventured to discuss how the scientific resources of the nation at war could be better utilized. That might involve not only the usual items of criticism and the usual items of defense which we have all heard, but also—if properly undertaken—an exposure of facts which must at present be kept secret and of difficulties due to the personal peculiarities of individuals. Unfortunately, when science comes, as it must come in war, into direct touch with action, it finds itself thwarted by intrigue, upset by unscrupulous exploitation of social and political connections, surrounded by personal ambitions and jealousies. These provide no small part of the difficulty in the way of utilizing our great scientific resources to the full. Blessed are they who remain innocently in their laboratories and grumble: for it is a thankless task to try to get things right.

One last word. In recent years a number of brilliant revolutionaries, filled with political zeal but without experience of affairs, have won great fame and applause by showing how science is going to change the face of society. The public is inclined to place these gentlemen on the same intellectual pedestal as Einstein, supposing that their science is as great as their chatter. The more responsible members of the scientific community are a little frightened by these activities—not because they grudge their colleagues their easy fame—but because the impression is put about that scientists as a whole claim to be allowed to dominate policy; and so, resistance is aroused to their more modest suggestion that they ought to be consulted. If these remarks should reach the ears of those on whom the task of formulating public policy falls, they can be reassured. The majority of scientific men are quite reasonable and have no grandiose ideas. We know our own limitations—as we are well aware of yours. All we ask is that we should be considered as equals in a common task—not merely as superior technicians paid to dish up the magic which you order.

ENERGY AT THE THRESHOLD OF VISION

By Professor SELIG HECHT, Dr. SIMON SHLAER, and MAURICE H. PIRENNE*

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LANGLEY[1] in 1889, after inventing the bolometer for measuring the energy of the solar spectrum, made the first determination of the minimum energy necessary to produce a visual effect. He found this to be 3×10^{-9} ergs for light of 550 mμ. Since then a dozen efforts have been made to redetermine this energy. Unfortunately, many of these attempts contained serious errors which invalidate them; indeed most of them involved no direct energy measurements, but relied on previously measured energy distributions in standard sources. Only three appear free from obvious error; these yield 0.66×10^{-10} ergs (Chariton and Lea[2]), $1.3\text{–}2.6\times10^{-10}$ergs (von Kries and Eyster[3]), and $1.6\text{–}3.5\times10^{-10}$ ergs (Barnes and Czerny[4]). Only the last values represent actual energy determinations by the authors.

These amounts lie so near the energy of a single quantum of light (3.84×10^{-12} ergs for 510 mμ) as to suggest that a small number of light quanta is necessary for a visual effect. Since the photodecomposition of visual purple in solution[5] probably has a quantum efficiency of 1, this would indicate that a small number of molecules is concerned in initiating a biological act, in particular a biological act involving the highest nerve centers. Because of these implications, we undertook last spring to make the measurements again, but under the best physical and physiological conditions so as to render the data reasonably definitive.

The physiological conditions which yield maximum retinal sensibility have been well explored in recent years. They involve dark adaptation, peripheral vision, small test fields, short exposures and selected portions of the spectrum. Our measurements were therefore made only after a 30-minute stay in the dark, with a circular retinal area subtending 10 minutes of arc situated 20° temporally on the horizontal axis of the retina, using homogeneous spectral light of wave-length 510 mμ presented as a flash 1/1000 second long, all of which are known to represent the best conditions.

The physical arrangements involved a ribbon filament lamp run on current from storage cells controlled with a potentiometer, a calibrated filter for coarse intensity variation and a calibrated wedge for fine intensity control, a double monochromator, a precision shutter, a fixed pupil, a diaphragm for test-field size and a fixation point. The energy at the pupil was measured on two occasions several months apart with excellent agreement using a Hilger linear thermopile and a Paschen galvanometer after due calibration with a standard carbon filament lamp.

The results have been consistent over several months. For a half dozen observers in the laboratory the minimum energy necessary for vision ranges between 2.2 and 5.7×10^{-10} ergs at the cornea. These small energies represent between 58 and 148 quanta of blue-green light.

These are the values at the cornea. Before one can know how many quanta are actually absorbed by the retina, at least three corrections must be applied. The first is reflection from the cornea; this is about 4 per cent., and is of only slight importance. The second involves loss by the ocular media between the outer surface of the cornea and the retina. Contrary to common opinion this loss is large. From the measurements of Ludvigh and McCarthy[6] it appears that at 510 mμ the ocular media transmit almost exactly 50 per cent. of the light entering the cornea of a young person, and less for an older one.

The next correction is more difficult to evaluate with precision and involves the percentage of the energy absorbed by the visual purple in the retinal rods. Koenig's[7] measurement of the visual purple in a human eye yields an absorption of only 4 per cent. of light of 510 mμ on the assumption that visual purple is evenly spread over the retina. Though astonishingly small, this value is like the 4 per cent. and 13 per cent. recently found by Wald[8] for the absorption of the rabbit and rat retinas, respectively. These figures are probably too low, because visual purple is not evenly distributed over the retina; it is missing from the fovea, and even in the periphery the density of rods varies obviously.

We have estimated the concentration of visual purple in the retina in a completely independent manner by comparing the percentage absorption spectrum of different concentrations of visual purple with the dim (rod) vision luminosity curve of the spectrum[9]

* Fellow of the Belgian American Educational Foundation.

[1] S. P. Langley, *Phil. Mag.* (5), 27: 1, 1889.

[2] J. Chariton and C. A. Lea, *Proc. Roy. Soc.* A, 122: 304, 1929.

[3] J. v. Kries and J. A. E. Eyster, *Z. Sinnesphysiol.*, 41: 394, 1907.

[4] R. B. Barnes and M. Czerny, *Z. f. Phys.*, 79: 436, 1932.

[5] H. J. A. Dartnall, C. F. Goodeve and R. J. Lythgoe, *Proc. Roy. Soc.* A, 164: 216, 1938.

[6] E. Ludvigh and E. F. McCarthy, *Arch. Ophth.*, 20: 37, 1938.

[7] A. Koenig, *Sitzungsber. Akad. Wiss. Berlin*, 577, 1894.

[8] G. Wald, *J. Gen. Physiol.*, 21: 795, 1938.

[9] S. Hecht and R. E. Williams, *J. Gen. Physiol.*, 5: 1, 1922.

corrected for quantum effectiveness[10] and ocular media absorption.[6] The comparison rests on the fact that the shape and width of the percentage absorption spectrum of a substance varies with its concentration, and that the corrected luminosity curve must represent the percentage absorption curve of a particular concentration of visual purple in the retina. Using the average of the almost identical measurements of frog's visual purple made by Chase and Haig,[11] by Lythgoe[12] and by Wald,[8] we find that visual purple absorption and retinal luminosity coincide for such a concentration of visual purple that at 510 mμ the absorption is between 10 and 20 per cent. An absorption above 20 per cent. is definitely excluded, and one may therefore take this as an upper limit; it is still of the same order of magnitude as the values found by Koenig and by Wald.

If we apply these three corrections to the minimum perceptible energy, the range of 58 to 148 quanta at the cornea becomes as an upper limit 5 to 14 quanta absorbed by the retina. It is quite probable that the higher value, which is given by the oldest (48 years) observer, is the result of a much higher absorption by his lens, and that the range is really much smaller than would appear.

The area on the retina in which these few quanta are absorbed contains about 500 sensitive receptor cells. The likelihood, therefore, that 2 quanta will be taken up by a single rod cell is only about 4 per cent. We can then conclude that in order to see, it is necessary for only 1 quantum of light to be absorbed by each of 5 to 14 retinal rods. Taking a quantum efficiency of 1 for visual purple, this means that one molecule of visual purple needs to be changed in each of 5 to 14 rods in order to produce a visual effect.

This is indeed a small number of chemical events; but by virtue of its very smallness one may test its reality in an entirely independent manner.

The energy calibration of the light gives merely the *average* number of quanta per flash. Each flash will not always deliver this average number; sometimes the flash will yield fewer, sometimes more quanta. Since each quantum absorption in the retina is a discrete, independent and random event, the actual number of such retinal events which any given flash provides will vary according to a Poisson probability distribution.

The virtue of the Poisson distribution is that its properties depend only on the value of the average number. Assume for the moment that for us to see a flash of light, the retina must absorb n quanta; obviously we shall also see it if the retina absorbs more than n quanta. From the Poisson distributions one can then compute the probability that n or more quanta will be delivered to the retina in a given flash when the average number of quanta delivered by that flash is known. These computed values are shown in Fig. 1.

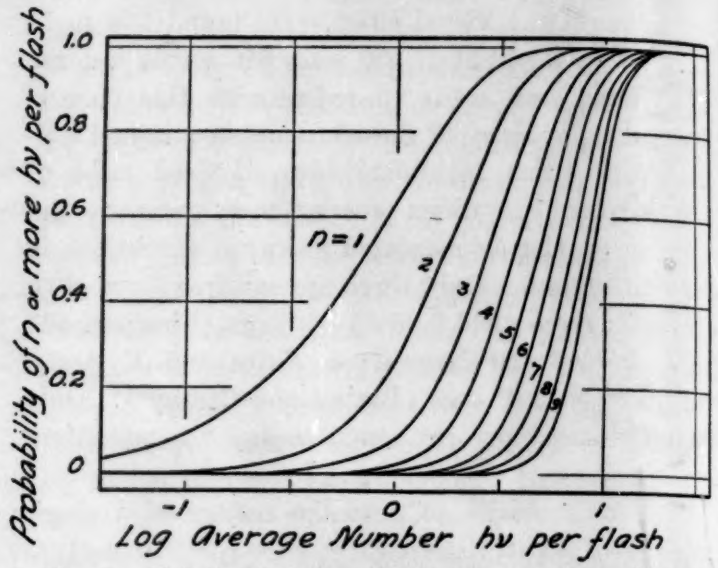

FIG. 1. Relation between the average number of quanta ($h\nu$) per flash of light and the frequency with which the flash will contain n or more quanta, computed in terms of the Poisson probability distribution.

The significant feature of Fig. 1 is that the shape of the probability distribution is fixed and different for every value of n; the curve becomes steeper as n increases. It therefore follows that if the probability distribution could be determined by experiment, its *shape* would automatically reveal the value of n corresponding to it. What is equally important is that in the experimental procedure for determining the probability distribution, the absolute values of the average number of quanta per flash are not necessary for comparison with the distributions in Fig. 1. Because of the logarithmic plot, the relative values of the average number are adequate to determine n.

Experimentally one should see a flash whenever it yields n or more quanta of light to the retina. On frequent repetition of a flash of given average quantum content, the frequency with which the flash is seen will depend on the probability with which it yields n or more quanta to the retina. When this frequency is determined for each of several intensities, a frequency distribution is secured whose shape, when plotted against the logarithm of the average energy content, should correspond to one of the probability distributions in Fig. 1 and thus show what the value of n has been.

We have made determinations of this kind. Unknown to the observer, the experimenter varies the intensity of the light. The observer elicits the flash,

[10] H. J. A. Dartnall and C. F. Goodeve, *Nature*, 139: 409, 1937.
[11] A. M. Chase and C. Haig, *J. Gen. Physiol.*, 21, 411, 1938.
[12] R. J. Lythgoe, *J. Physiol.*, 89: 331, 1937.

and reports whether he saw it or not. This is done for six intensities which are presented in a deliberately random sequence, each for 50 times. A series takes about one and one half hours.

The data for us three are given in Fig. 2. Com-

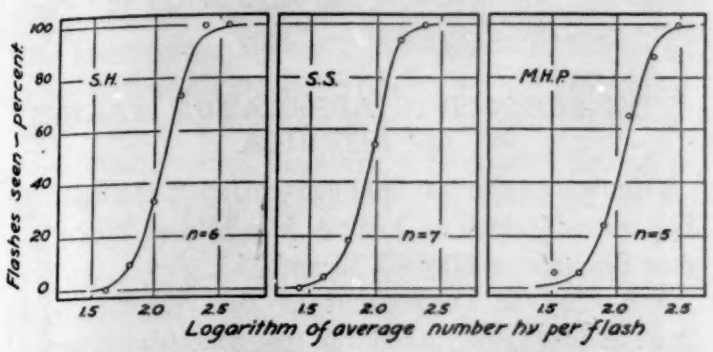

FIG. 2. Relation between the average number of quanta delivered by a flash of light at the cornea and the frequency with which the observer sees the flash. The curves are the computed Poisson distributions taken from Fig. 1. Each point represents 50 observations.

parison with the curves in Fig. 1 shows that the measurements are fitted best by Poisson distributions in which n is 5, 6 and 7 quanta per flash. Smaller and larger values of n are definitely excluded. Thus the number of critical physical events necessary in the retina in order to produce a visual effect lies between 5 and 7. This is in excellent agreement with the results determined by the straightforward physical measurements. We must therefore consider them as the actual number of quanta absorbed by the retina for the initiation of a visual act.

In applying the Poisson probability distribution, we have assumed that a constant number of quanta is necessary in order to see a flash of light. In view of the supposed variability of an organism from moment to moment, we have considered the consequences of assuming this number n to vary. An example will make this clear. Suppose that the biological variation lies between 5 and 9 quanta per visual act, and that it has an ordinary probability distribution. The curves in Fig. 1, weighted in such a way and averaged, yield a curve which is identical with the ones in Fig. 1 for $n=5$ or 6. Thus when biological variation is imposed upon the physical variation there occurs no change in the essential characteristics of the physical distribution and only a small decrease in the value of n. When, as in Fig. 2, the measurements yield n values of 5, 6 or 7, these represent lower limiting values for the physical number of quanta.

In considering the nature of fluctuations in response given by an organism, it has always been assumed that the stimulus is constant and that the organism is variable. The present evaluation of our measurements shows however that at the threshold, where only a few quanta of energy are involved, it is the stimulus which is variable, and that the nature of its variability determines the variation encountered between response and stimulus.

SCIENTIFIC EVENTS

THE COLLEGE OF SURGEONS, LONDON

THE following account of the damage by air raids to the Royal College of Surgeons, London, is given in the London *Times* for May 21:

Irreparable losses, including most of the Hunterian Collection, were suffered by the Royal College of Surgeons in Lincoln's Inn Fields, whence the society moved from their eighteenth-century hall in the Old Bailey. Incendiary bombs first fell on the roof of the building, but just as a watcher was giving the alarm a high-explosive missile struck No. 5 room of the museum. Only two persons on the premises were slightly injured. In spite of great damage to the interior the fabric of the college is more or less intact, but the museum buildings have suffered severely, and fire also gutted an adjoining building containing solicitors' offices and the College of Estate Management.

The most valuable specimens in Dr. John Hunter's collection, purchased by the Government for £15,000 two years after his death in 1793 and presented to the college, are probably safe under the débris, having previously been moved into reinforced sections of the subbasement. The collection of portraits and pictures, including Reynolds's portrait of Hunter, are safe in the country, and the part of the records still at the college had been stored in strong rooms that withstood the blast and flames.

But thousands of museum pieces are gone, among them the skeletons of kangaroos brought by Captain Cook from Australia, and the comparative osteology collection of 4,000 specimens acknowledged to be the finest in the world. Much of the material antedated British Museum specimens, and, as Professor Cave, the assistant conservator, said yesterday, the greater part of the wonderful work of Sir Richard Owen and Dr. William Flower has been undone.

All Dr. Hunter's eighteenth-century furniture, which was in the president's room, was destroyed. The original surgical instruments used by Lister were recovered, but many others were lost. Though the oldest mummy in the world, that of Ra Nefer, an Egyptian nobleman who died, it is said, about 2900 B.C., was destroyed, many mummies of popular interest have been salved.

By a grim coincidence the invaluable Army Medical War Collection, containing plaster casts of every type of wound, was also destroyed, as were the council room and lecture theater.

NATURE PROTECTION AND WILDLIFE PRESERVATION

THE following resolution on the protection of nature in the Americas was adopted on May 8 at the annual meeting of the Board of Trustees of the National Parks Association:

Since the Treaty on Nature Protection and Wildlife Preservation in the American Republics (Western Hemisphere) has already been signed by the representatives of seventeen countries, including the United States; and

Since this inter-American treaty was ratified by the United States Senate on April 7, 1941; and

Since this treaty has also been ratified by one other country and, following its expected early ratification by three others, will come into force three months after deposit of these five ratifications with the Pan American Union;

BE IT THEREFORE RESOLVED, That enabling legislation should be enacted and executive orders or decrees issued in all countries signatory to the treaty, to implement it and effectuate its purposes at the earliest possible date; and

BE IT FURTHER RESOLVED, That the National Parks Association commends the following international organizations for their continuing efforts to promote the protection of Nature in the Americas:

The Pan American Institute of Geography and History,

The American Committee for International Wild Life Protection, and

The Pan-American Section of the International Committee for Bird Preservation.

According to a statement issued by the association the integrity of national monuments throughout the country is endangered by current Congressional legislation. The association has called upon the Congress to adhere to its policies of public land use. In part the statement reads:

A Congressional bill to permit mining within the Organ Pipe Cactus National Monument in Arizona has passed the Senate and is now pending in the House of Representatives. Objection was made to its consideration on the consent calendar by Congressman Cole of New York on June 2, on the grounds that such legislation would be unnecessarily destructive and set an undesirable precedent for mining in other national monuments. Opponents of the bill point out that, according to the organic act that created the National Park Service in 1916, the purpose for which national parks, monuments and reservations are established is "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." On the sound basis of that act, it has been the settled policy of the Federal Government that mineral development be forever excluded from these areas.

Recent investigations of the monument have been made by representatives of several scientific organizations, particularly the Ecological Society of America and the Natural History Museum of San Diego, California. Their first-hand reports prove that the continued existence of the native plant and animal associations requires preservation of the entire area in essentially unmodified condition. It is shown to be the only area of its kind in the United States that is both diverse and large enough to preserve the original biotic community.

THE SCIENTIFIC APPARATUS MAKERS OF AMERICA

THE twenty-third annual convention of the Scientific Apparatus Makers of America was held at White Sulphur Springs on May 12, 13 and 14.

According to an account of the meeting in the *News Edition*, published by the American Chemical Society, "Industrial Relations" was the subject of the first session, which was presided over by C. S. Redding, president of the Leeds and Northrup Company. The speakers included H. B. Allen, secretary and director of the Franklin Institute and chairman of the Philadelphia Advisory Council on Vocational Education for National Defense; L. C. Mueller, New York Army Ordnance District, and A. C. Horrocks, public relations director, Goodyear Tire and Rubber Company.

At the annual dinner on May 13 Professor George R. Harrison, director of the laboratory of experimental physics of the Massachusetts Institute of Technology, gave an address on scientific instruments in war and after.

On Wednesday morning Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry*, made a presentation on the subject of priorities which was followed by a discussion.

Officers of the society were elected as follows: C. G. Campbell, Kewaunee Manufacturing Company, was reelected chairman of the board, J. M. Roberts, president, and P. E. Klopsteg, secretary-treasurer. Directors are C. S. Redding, Leeds and Northrup Company; W. H. Curtin, W. H. Curtin Company; C. G. Campbell, Kewaunee Manufacturing Company; I. L. Nixon, Bausch and Lomb Optical Company, and Thomas Lord, C. F. Pease Company. Directors-at-large are R. E. Gillmor, Sperry Gyroscope Company; C. S. Hallauer, Bausch and Lomb Optical Company; J. A. Hartley, Braun Corporation, and F. K. Taylor, Taylor Instrument Company.

THE HUNDREDTH ANNIVERSARY OF THE COLLEGE OF LITERATURE, SCIENCE AND THE ARTS OF THE UNIVERSITY OF MICHIGAN

THE centennial anniversary celebration of the College of Literature, Science and the Arts of the University of Michigan will take place on October 5,

when there is planned a discussion of the problems and the future of liberal arts education. The first classes in the College of Literature, Science and the Arts were held on September 25, 1841. A full day's program has been planned for the centennial. Dr. Edward H. Kraus, dean of the college and chairman of the committee, is in charge of the celebration.

The morning session will be devoted to addresses on the development and achievements of the college by present members of the faculty. In the afternoon, several distinguished speakers will discuss the problems and the future of liberal arts education in the United States.

Dr. Jesse S. Reeves, William W. Cook professor of American institutions, will open the morning session with an address on the general development of the college. Achievements of the college in language and literature will be discussed by Professor J. G. Winter; achievements in science, by Professor A. F. Shull, and achievements in the arts and social sciences, by Professor A. E. R. Boak.

The afternoon speakers will be: Dr. Marten ten Hoor, dean of the College of Arts and Sciences, Tulane University; Dr. George Clarke Sellery, dean of the College of Letters and Science, University of Wisconsin; Henry Allen Moe, secretary-general of the Guggenheim Memorial Foundation, and Judge Florence Ellinwood Allen, of the U. S. Circuit Court of Appeals.

The celebration will be concluded with a convocation, at which the principal speaker will be Dr. James Rowland Angell, president-emeritus of Yale University, previously professor of psychology at the University of Chicago, at present educational counselor of the National Broadcasting Company, an alumnus of the University of Michigan.

CELEBRATION AT RUTGERS UNIVERSITY

DURING the past academic year Rutgers University has been celebrating the one hundred and seventy-fifth anniversary of the founding of Queen's College in 1766. A series of convocations, at which lectures in seven different fields of learning have been given, were concluded in April. Lecturers and their subjects were as follows: William T. McLeery, journalism; Wesley C. Mitchell, economics; Karl K. Darrow, physics; Wheeler McMillan, agriculture; Harold W. Thompson, American folklore; F. R. Moulton, astronomy, and J. O. Perrine, engineering.

The closing exercises of the celebration will be held on October 9, 10 and 11 and will consist of a series of addresses and symposia in four fields of learning. They will "provide opportunities for scholars to discuss and correlate present knowledge and to consider subjects for future research."

All students and scholars who can benefit from the meetings are cordially invited to attend. Invitations are now being sent to teachers and research workers in colleges, universities and institutions of the United States and Canada. Those not receiving such an invitation may write directly to the One Hundred and Seventy-fifth Anniversary Celebration, Rutgers University, New Brunswick, New Jersey, for information.

The provisional program in science is as follows:

October 9—Applied Science I—Address by Karl T. Compton, "Scientists Face the 1942 World."

Applied Science II—Symposium—Vannevar Bush, "The Case for Biological Engineering," and Robert W. Trullinger, "The Case for Agricultural Engineering."

October 10—Natural Science I—Address by Hugh Stott Taylor, "Fundamental Science from Phlogiston to Cyclotron."

Natural Science II—Symposium—Irving Langmuir, "Films in Chemistry and Biology," and Ernest O. Lawrence, "Nuclear Physics and Biology."

The final anniversary convocation will be held on October 11, at which Clarence Dykstra will deliver an address and honorary degrees will be conferred. Various social events have been planned for the evenings and for Saturday afternoon.

HONORARY DEGREES RECENTLY CONFERRED ON SCIENTIFIC MEN

DR. JOHN H. NORTHRUP, of the Rockefeller Institute for Medical Research, Princeton, N. J., received on June 8 the doctorate of science from Rutgers University.

AT the commencement exercises of the Polytechnic Institute of Brooklyn an honorary degree was conferred on Dr. Vannevar Bush, president of the Carnegie Institution and chairman of the National Defense Research Committee.

DR. CARL E. LADD, dean of the New York State Colleges of Agriculture and Home Economics at Cornell University, received the degree of doctor of laws at the commencement exercises of the University of Maine.

HAVERFORD COLLEGE on June 7 conferred the degree of doctor of laws on Herbert Hoover, formerly president of the United States. Mr. Hoover gave the commencement address.

PURDUE UNIVERSITY on June 8 conferred the degree of doctor of laws on Secretary of Agriculture Claude R. Wickard, who is an alumnus of the university.

BETHANY COLLEGE, West Virginia, at its hundredth commencement on June 9, conferred the doctorate of laws on Dr. Herbert E. Hawkes, professor of mathematics and dean of Columbia College.

AMONG degrees conferred by Union College were the doctorate of laws on Philip Dunham Reed, chairman of the board of directors of the General Electric Company

and senior consultant of the priorities division of the Office of Production Management, and on Edward R. Stettinius, Jr., director of the priorities division of the Office of Production Management.

AT the commencement exercises on June 8 of the Iowa State College, the degree of doctor of laws was awarded to Robert Emery Neff, superintendent of hospitals for the State University of Iowa, for "outstanding work in the field of hospital administration." Henry J. Brunnier, of San Francisco, received the Marston Medal in recognition of his contribution to the structural safety of buildings and bridges of the Pacific Coast—particularly the San Francisco-Oakland Bridge.

THE doctorate of science was conferred at the commencement of New York University on Dr. John Joseph Morehead, consulting surgeon of the New York Post-Graduate Medical Hospital, and on Dr. George Barclay Wallace, professor of pharmacology and therapeutics and director of the pharmacological laboratories of the New York University College of Medicine. The doctorate of public health was conferred on Dr. William Edgar Caldwell, professor of clinical obstetrics and gynecology at Columbia University, and on Dr. Frederick Clark Holden, professor emeritus of obstetrics and gynecology in the New York University College of Medicine.

DEATHS AND MEMORIALS

DR. OWEN LOUIS SHINN, professor of applied chemistry at the University of Pennsylvania, died on June 10 at the age of sixty-nine years. He had been associated with the university as a student and faculty member for more than fifty years.

DR. SIDNEY ARMOR REEVE, of New York City, consulting engineer, retired, from 1898 to 1916 professor of steam and hydraulic engineering at the Worcester Polytechnic Institute, died on June 12 at the age of seventy-five years.

CHARLES WHITING BAKER, consulting engineer, retired, since 1911 commissioner of the Palisades Interstate Park, died on June 5 at the age of seventy-six years.

LORIN EVERETT IMLAY, electrical engineer, director of statistics of the Niagara Hudson Power Corporation, who was associated with the Pioneer Tunnel Power Development at Niagara, died on June 10. He was seventy-six years old.

DR. JULIUS FRIEDENWALD, professor emeritus of gastro-enterology at the Medical School of the University of Maryland, a member of the faculty for more than forty years, died on June 8 at the age of seventy-four years.

DR. WILBUR HARRINGTON NORCROSS, professor of psychology at Dickinson College, Carlisle, Pa., died on June 11. He was fifty-eight years old.

LELAND MASON WILLEY, purchasing agent and accountant for the General Electric Company, Schenectady, N. Y., died on May 21 at the age of fifty-eight years.

IN memory of Professor Louis H. Pammel, whose death in 1931 ended a period of forty years of service in Iowa State College, a tract of woodland in the college grounds was dedicated on June 7 as Pammel Park. Preserving the natural beauty of the land, it will especially commemorate Mr. Pammel's zeal and devotion in the cause of conservation throughout the state.

SCIENTIFIC NOTES AND NEWS

DR. FREDERICK WHARTON RANKIN, surgeon, of Lexington, Ky., was elected at the Cleveland meeting president of the American Medical Association.

DR. WALTER S. LANDIS, vice-president of the American Cyanamid Company, has been elected president of the Chemists' Club, New York. Dr. Edward A. Dieterle, consulting gas and chemical engineer, has been elected president of the Chemists' Club, Chicago.

NATIONAL officers of the American Association of Scientific Workers for 1941–1942 have been elected as follows: *President,* Professor Anton J. Carlson, University of Chicago; *Vice-presidents,* Professor C. Fayette Taylor, the Massachusetts Institute of Technology; Watson Davis, Science Service; Professor Ralph W. Gerard, University of Chicago; Professor Edward C. Tolman, University of California at Berkeley; *Treasurer,* Professor H. Burr Steinbach, Columbia University; *Secretary,* Dr. Harry Grundfest, Rockefeller Institute for Medical Research. In the Chicago branch, the new officers are: Professor R. W. Gerard, *president;* Professors R. S. Mulliken and E. S. G. Barron, *vice-presidents;* Professor B. F. Miller, *president-elect;* Dr. Zelma Baker, *recording secretary;* Dr. Albert Dorfman, *corresponding secretary;* M. Silver, *treasurer.* The new officers of the New York branch are: Professor Walter Rautenstrauch, *chairman;* Dr. Oscar Bodansky, *treasurer;* Miss Doris P. Flavelle, *secretary.*

THE Revere Award of $5,000 has been given to Eugene Phillips in recognition of his invention of a blind-landing system for aeroplanes. The award was presented to him at a dinner given in his honor on

June 9 by C. Donald Dallas, president of the Revere Copper and Brass Company, donor of the prize.

AT a recent meeting of the council of the Royal Agricultural and Horticultural Society of India, Dr. C. Stuart Gager was elected to honorary membership in the society.

FOR his paper presented at the annual meeting in 1940 of the American Society for Testing Materials, on "The Tension Test," C. W. McGregor, associate professor of mechanical engineering at the Massachusetts Institute of Technology, will be presented on June 25 with the Charles B. Dudley Medal at the forty-fourth annual meeting, which will be held in Chicago. The award commemorates the name of the first president of the society and is given to the author of an original contribution "of outstanding merit" presented at the previous annual meeting.

THE Hanbury Medal of the British National Institute for Medical Research has been awarded to Dr. Harold King for "high excellence in the prosecution of original research in the natural history and chemistry of drugs."

DR. HENRY K. BEECHER, associate in anesthesia at the Harvard Medical School, has been appointed to the Dr. Henry Isaiah Dorr chair of research and teaching in anesthetics and anesthesia.

DR. CLARENCE H. GRAHAM has been promoted to a professorship of psychology at Brown University.

DR. IRA L. BALDWIN, professor of bacteriology and assistant dean of the College of Agriculture of the University of Wisconsin, has been appointed head of the department of agricultural bacteriology. He succeeds Professor Edwin George Hastings, who has served since 1910 and who has been relieved of the chairmanship at his own request in order that he may devote his time to other departmental work.

JOSEPH K. NICHOLES, of Brigham Young University, has been promoted from an associate professorship to a professorship of chemistry.

DR. ARNOLD MARTIN KUETHE, aeronautical engineer of the Advisory Committee on Aeronautics, has been appointed associate professor of aeronautical engineering at the University of Michigan. He succeeds Dr. Milton J. Thompson, who resigned in February.

DR. DOROTHY M. WRINCH, of Oxford, lecturer in chemistry at the Johns Hopkins University, has been appointed to a joint visiting professorship at Smith, Mt. Holyoke and Amherst Colleges for the academic year 1941–42. At each institution she will conduct a series of seminars in the general field of molecular biology.

DR. RALPH W. PHILLIPS, head of the department of animal husbandry of the Utah State Agricultural College, will direct investigations in animal genetics at the Beltsville, Md., Research Center. He will begin his work on July 1. The position has been vacant since the resignation in March, 1940, of Dr. W. V. Lambert.

JEROME F. GRATTAN, formerly research chemist at the Squibb Institute, has joined the recently organized research staff of the International Vitamin Corporation of New York, N. Y.

THE Carnegie Institution of Washington has renewed its grant for research in high precision calorimetry in the department of chemistry of the University of Pittsburgh for the college year 1941–42. The post-doctorate fellow reappointed is William E. Wallace, whose work will be under the direction of Dr. A. L. Robinson.

RODNEY E. BLACK, Pawhuska, Okla., has been awarded the thirteenth Weston fellowship of the Electrochemical Society, which is of the value of $1,000. He is investigating the plating of molybdenum and tungsten alloys at the University of Wisconsin.

THE University of Texas has been awarded a grant of $34,520 for research in genetics by the Rockefeller Foundation for the study of the question of how new species and races of animals arise in nature. The work will be under the direction of Dr. J. T. Patterson, professor of zoology; Dr. Wilson S. Stone, associate professor of zoology, and Dr. A. B. Griffen, research associate in the university's Research Institute. This grant follows by two weeks another Rockefeller grant for the establishment of the first laboratory of marine biology on the Gulf of Mexico.

ACCORDING to *Nature,* Dr. L. G. M. Baas-Becking, professor of botany in the University of Leyden and director of the Leyden Botanical Gardens, is now in custody in a prison at Scheveningen, Holland.

A PARTY from the department of geology and geography at Northwestern University will be engaged through the summer in the study of the pre-Cambrian rocks of the Los Pinos Range in central New Mexico. Drs. J. T. Stark and E. C. Dapples are in charge of the work, and will be assisted by Ralph Wilpolt, Mortimer Staatz, James Norton and Hugh Garrison. The project is financed by a grant from the university.

THE officers, executive committee and members of the Division of Geology and Geography of the National Research Council, for the year beginning July 1, are as follows: *Chairman,* Walter H. Bucher; *Vice-chairman,* Richard Hartshorne; *Executive Committee,* Walter H. Bucher, Richard Hartshorne, Wilmot H.

Bradley, Charles C. Colby, A. I. Levorsen, T. S. Lovering; *Representatives of Societies,* Wilmot H. Bradley and T. S. Lovering, Geological Society of America; George Tunell, Mineralogical Society of America; G. Arthur Cooper, Paleontological Society; Richard Hartshorne and Richard J. Russell, Association of American Geographers; Charles B. Hitchcock, American Geographical Society; Wilbur S. Burbank, Society of Economic Geologists; Robert B. Sosman, American Ceramic Society; A. I. Levorsen, American Association of Petroleum Geologists; *Members at Large,* Walter H. Bucher, Charles C. Colby and Joseph T. Singewald, Jr.

DR. ANTON J. CARLSON, Frank P. Hixon professor of physiology at the University of Chicago, delivered on June 8 the commencement address at the Massachusetts Institute of Technology.

DR. ALAN GREGG, director for the medical sciences of the Rockefeller Foundation, delivered on June 11 the commencement address at the Cornell University Medical College.

DR. H. H. NEWMAN, professor emeritus of zoology of the University of Chicago, addressed the Purdue University Chapter of the Society of the Sigma Xi on May 16 at the annual banquet of the chapter. The subject of the lecture was "Human Twins and Multiple Births."

A JOINT conference on "Science in the Service of the Consumer" of the Consumers Union of the United States and the American Association of Scientific Workers was held on June 17 and 18 in connection with the seventy-fifth anniversary celebration of the University of New Hampshire. At the dinner meeting on the evening of June 18, Dr. Anton J. Carlson, chairman of the department of physiology at the University of Chicago, president of the American Association of Scientific Workers, gave an address on "Poisons in Food."

THE recent agitation in Washington and elsewhere concerning wildlife conservation, the attention which is being directed toward soil conservation and land utilization, and the program of conservation education of the National Wildlife Federation, has focused the attention of those interested upon the necessity of concentrated effort. New Hampshire is fortunate in its wealth of scenic beauty and abundance of wildlife, but at the same time has many conservation problems. A meeting was held in Concord on May 4, 1940, composed of representatives from several organizations, to discuss the desirability of calling a general conference to consider the possibility of perfecting a federation of organizations interested in conservation education. H. E. Warfel, of the State Fish and Game Department; E. H. Little, of the State Board of Education, and H. B. Holbrook, of the Boy Scouts organization, were appointed a committee to organize the conference. The response of organizations within the state to the invitation to this conference has been nearly a hundred per cent. The committee will hold a meeting under the auspices of the Biological Institute in conjunction with the seventy-fifth anniversary celebration of the university, and a program has been arranged for June 24 at Durham. The conference will be composed of delegates of over fifty organizations, including state departments in addition to others who are interested in the conservation of the resources of the state.

THE newly established position of director of public health and preventive medicine in the Medical School of the University of Oregon was provided for through a bequest of $400,000 to the Oregon State System of Higher Education by the late Dr. E. C. Brown, physician of Portland. The bequest provides for the establishment of a perpetual trust, the income of which is to be used to "carry on the instruction and education of the boys and girls and young people of the State of Oregon in respect to what is commonly called 'social hygiene,'" under the direction of the executive head of the University of Oregon. Within terms of the will, the director will devote one third of his time to instructional work at the Medical School, and the remainder to such educational work throughout the state as will carry out the provisions of the will.

ARTHUR CURTISS JAMES, railroad industrialist, who died on June 1, bequeathed nearly eight tenths of his estate for the establishment of the James Foundation, the income of which is to be used to aid charitable, religious and educational institutions. Mr. James directed that the board of the foundation use part of the funds vested in it from time to time to further the work of certain charitable, religious and educational institutions to which he had made substantial contributions. He directed that the income be divided into twenty-eight shares. Among those receiving two shares are Amherst College, the Metropolitan Museum and the Presbyterian Hospital, New York. One share goes to the New York Public Library and one to the American Museum of Natural History.

THE Rockefeller Foundation has provided a grant of $90,000 "to aid hard-pressed research projects at the University of Rochester's School of Medicine and Dentistry." The grant extends over three years with the sum of $30,000 available each year. Appropriations from the fund will be made to promising investigations which would otherwise have to be given up or curtailed due to decreasing income from the university's endowment.

THE Oregon State College has acquired a collection of mounted birds and bird eggs, gathered for the past fifty-six years by Mr. and Mrs. J. C. Braly, of Depoe Bay, Ore. The collection, which has been conservatively valued at $77,000, included 32,500 eggs, 1,000 mounted birds, 1,200 bird skins and 100 mounted mammals. There is an almost complete representation of Oregon birds, a large number from the Pacific coast, as well as many from other parts of the United States and foreign countries.

THE Committee on the Elizabeth McCormick Child Research Grant of the Institute of Medicine of Chicago has at its disposal the sum of $1,500 which may be awarded to qualified investigators in the Chicago area for the aid of research in child welfare. Applications will be received up to October 15, and the award will be made soon after. Communications should be addressed to Dr. John Favill, Secretary, 122 South Michigan Avenue, Chicago. Since there are no formal blanks, application should be made by letter.

THE department of electrical engineering of Columbia University, of which Professor Frederick W. Hehre has been elected chairman, will offer a new sub-option to its regular power option, to be known as the electrochemical power option, leading to the usual degrees of B.S. or of E.E. or M.S. in electrical engineering. Prepared with the assistance of Dr. Colin G. Fink, of the department of chemical engineering, and Dr. Eric R. Jette, of the department of metallurgy, this sub-option is intended to afford training for electrical engineers anticipating employment in the electrochemical or electrometallurgical industries.

DISCUSSION

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY

IN a letter dated the 14th of February, 1941, from the Rev. H. McLachlan, Unitarian College, Victoria Park, Manchester, to Dr. John F. Fulton, Yale University, it has been learned that the Eighteenth Century Library and Dalton relics belonging to the Manchester Literary and Philosophical Society have been destroyed by aerial warfare. As the society is one of the earliest of its kind, in Great Britain, having been founded in 1781, and because of its association with Dalton and Joule, it is felt that a brief report of its early activities should be placed on record.[1]

The early history of the society is linked with that of the Warrington Academy (1757–1784), for Thomas Percival, the "father" of the society, was a pupil at this school where he came under the influence of Priestley. Percival studied medicine in Edinburgh and in 1767 opened a consulting practice in Manchester, where he devoted his energies to problems in public health and epidemiology.

Possessing a charming personality and a keen mind with wide interests Percival soon began to attract the intellectual and talented men around him. Amongst those who attended the informal meetings in his home in King Street, was another notable figure in medicine, Charles White, surgeon to the Manchester Infirmary and pioneer in modern obstetrical practice, and author of the classical account of puerperal fever. White was no doubt the most original thinker in the circle of friends who began to collect at Percival's house. "These meetings became so pleasant, and the conversation so important, that many persons sought to attend, so that the resources of a private house were strained." Meetings were therefore held in a house in George Street, and finally in 1781 the society was formally established under the name of the Literary and Philosophical Society of Manchester.

Membership was at first limited to fifty, and it included the names of many other medical men, renowned in Manchester medical history, John Aikin, Peter Mainwaring, Thomas Henry, Alexander Eason, George Bell and John Ferrier. It was decided "that the subjects of conversation comprehend natural philosophy, theoretical and experimental chemistry, polite literature, civil law, general politics, commerce and the arts. But that religion, and practical branches of physics, and British politics, be deemed prohibited, and that the chairman shall deliver his veto whenever they be introduced." A library was started almost immediately, and the society met weekly except during the summer months. The first meeting was held on March 14, 1781.

The society prospered, and the more important papers presented at the meetings were published in a series of Memoirs beginning in 1785 and continuing to the present day. It is not surprising, therefore, that when the Warrington Academy was compelled to close its doors in 1784 its supporters turned to Manchester, where the Literary and Philosophical Society was creating an atmosphere of intellectual curiosity unknown elsewhere in provincial England. Thus came into being the Manchester Academy, which subsequently, after much wandering, settled in Oxford as Manchester College.

In 1794 John Dalton was appointed tutor in mathematics and natural philosophy in the Manchester Academy, and in the same year was elected member of

[1] For a fuller account of the history of the society see D. Sheehan, *Isis*, 1941 (in press).

the society, which by this time had built its own house at 36 George Street, Manchester, where some of the rooms were placed at the disposal of Dalton. Dalton continued to work in these rooms up to the time of his death in 1844, and it was here that the atomic theory was born. Dalton's classical essay on color-blindness, a defect from which he suffered, was communicated to the society in the year of his election. Dalton served as president of the Manchester Literary and Philosophical Society from 1817 to 1844, and at his death, his manuscripts, apparatus and personal belongings (including his spectacles, walking stick and numerous medals) were presented to the society.

Two years before Dalton's death, James Prescott Joule was elected to membership, and served as president for several terms of office during the next forty years. A tradition in experimental physics was thereby established in Manchester, which was continued by Sturgeon, Rutherford and Bragg up to the present day.

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THE AGE OF SAUROPOD DINOSAURS

AN article entitled "The Age of Jurassic Dinosaurs," by Dr. Edward W. Berry, appeared in SCIENCE, n.s., Vol. 93, No. 2416, Friday, April 18, 1941, page 374. The last paragraph of this article read as follows: "All this leads into the question of the age of the Morrison. I have expressed my opinion long ago, and wish merely to raise the question in the present connection, that if a Jurassic dinosaur (vertebrate chronology) makes footprints at a horizon near the middle of the marine Lower Cretaceous (invertebrate chronology) where do we go from here?" This article calls for elucidation.

Since the first notice was published of *Apatosaurus* (*Brontosaurus*), *Diplodocus* and other types of sauropod dinosaurs from the Morrison formation of Colorado and Wyoming, much has been written about the age of the Morrison and its fauna. At present, I believe, most vertebrate paleontologists are agreed that the Morrison fauna is of Jurassic age, but a great many discoveries relating to sauropod dinosaurs have been accumulated of late years, and much of this information has not yet been published.

In the exposures south of the Black Hills the lowest Cretaceous strata are represented by the Fuson and Lakota formations and there is a definite break between these Lower Cretaceous beds and the Jurassic below, although the vertebrate faunas in these two formations are not well known in this area.

In Montana, surrounding the Big Horn and Pryor Mountains, the Cloverly formation which is contemporaneous, probably with the combined Fuson and Lakota of the Black Hills, carries a distinct early Cretaceous vertebrate fauna whose affinity is with the late Cretaceous faunas elsewhere. American Museum expeditions worked in this region for several years continuously from 1931 to 1934 and secured a large series of skeletons of typical Cretaceous dinosaurs, Trachodonts, Nodosaurs and a new type of Iguanodont not yet described from the Cloverly formation. No sauropod skeletons were found, but a great many sauropod limb bones were seen in these beds. The same fauna was found and collected in the Cloverly formation near Harlowton, Montana, and in a few instances sauropod bones were recognized by our parties in the typical Kootenai beds near Great Falls. Some vertebrae were collected that are apparently those of *Diplodocus* although the exact generic and specific identification is hazardous. In the Big Horn region *Barosaurus* and *Morosaurus* are abundant in the Jurassic strata where there is a distinct break between the Jurassic and Lower Cretaceous beds and it is certain that sauropod dinosaurs extended through into the Lower Cretaceous, but we are not sure that they are the same genera as those found in the Jurassic strata. It is certain, however, that the abundant Lower Cretaceous dinosaur forms are not found in the Jurassic beds below.

Until recently it had been my opinion that the sauropod dinosaurs of Jurassic age died out sometime before the varied and rich fauna of Upper Cretaceous times came into existence. This opinion, however, has been altered by the results of the National Museum expeditions which have discovered sauropod dinosaurs, *Alamosaurus,* and a yet undescribed genus of sauropods in the Upper Cretaceous beds of Utah.

In the Big Bend region of Brewster County, Texas, the Chisos Mountains are surrounded by a series of alternating sands and clays that have been named the Aguja formation (Rattlesnake fm.). These beds are rich in Cretaceous dinosaur remains, for the most part disassociated and badly broken, but occasionally with identifiable specimens. The American Museum expedition of 1940 secured a fairly large collection from these beds in which there are typical Trachodont, Ceratopsian, Ankylosaurian and crocodilian remains. The genera, for the most part, are recognizable, but the species are new and the faunal facies is comparable to that of the Mesaverde and Judith River formations farther north. The area is extensive and no sauropod remains were found in this formation.

Above the Aguja and so far as could be seen conformably overlying it are the Tornillo clays. This is a series predominantly of clays 1600+ or – feet in thickness in which none of the Trachodont, Ceratopsian or

Ankylosaurian dinosaurs are to be seen, but several remains of sauropods were found—some of gigantic size. Now as the Mesaverde and Judith River formations are fairly high up in the Cretaceous series it is determined that in the south, at least, climatic conditions of Jurassic times persisted well up into the upper part of the Cretaceous age, so that sauropods definitely extended through the Morrison Jurassic well up into Cretaceous times. It is our opinion that they did not exist to the very close of the Cretaceous as represented by Lance and Hell Creek times.

There is no doubt that the Glen Rose formation of Texas is Lower Cretaceous in age and in this formation we have found the first sauropod dinosaur footprints known. These tracks, of which there are several hundred, show distinctly that there were no claws on the front feet but they were unquestionably made by sauropod dinosaurs, probably an unnamed species, some of which are as large and larger than *Brontosaurus*. Similar tracks of the same character were found in Bandera County, Texas, and they have been found also in the Panhandle of Oklahoma. It is unfortunate that the article describing these tracks infers that they were made by a *Brontosaurus*. One of the characters distinguishing the genus *Apatosaurus* (*Brontosaurus*) is a single large claw on the first digit of the front feet. No tracks of *Brontosaurus* are known, but the Glen Rose tracks were definitely made by a sauropod dinosaur closely related to and of the same size as the mounted *Brontosaurus* in the American Museum and it is proposed to place a series of these tracks under the mounted skeleton in order to show the size and stride of the feet of a similar living animal.

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WESTWARD SPREAD OF EASTERN TYPE EQUINE ENCEPHALOMYELITIS VIRUS

ON the North American continent, two types of immunologically distinct viruses of equine encephalomyelitis have been recognized, Eastern type and Western type. The areas in which these virus types have been isolated have had a sharp line of demarcation defining their boundaries in the Appalachian chain of mountains. Until 1939, these limits were without exception, but in that year a few cases of both types were isolated in the state of Alabama.

On April 29, 1941, portions of a horse brain from a civilian owned animal were received by the Veterinary School, Army Medical Center, Washington, D. C., from Colonel Clifford O. Whitney, V.C., of Fort Brown, Brownsville, Texas. The specimen originated from that area southeast of Brownsville, Texas, bordering on the Gulf of Mexico and known as the "Boca Chica flats." Sixty horses had recently been reported in this area as having died of suspected encephalomyelitis.

Accordingly, 0.1 cc of a 1–500 dilution of an emulsion of portions of the cerebrum and hippocampus from the specimen were inoculated intracerebrally into 3 normal guinea pigs. Within 72 hours all three had developed typical symptoms of encephalomyelitis, one died and two were destroyed while moribund in order to recover their brains.

A 1–500 dilution of an emulsion of portions of these 2 brains was then inoculated intracerebrally in 0.1 cc amounts into 3 groups of guinea pigs, one group immunized against the Western type virus, the second group immunized against the Eastern type and a third group of normal control animals.

The animals belonging to the Western immune type and the normal controls succumbed within less than 72 hours with typical encephalomyelitis symptoms, while the animals of the Eastern immune type remained normal.

Since the Western immune type guinea pigs were affected while the Eastern remained normal, this combined with the short incubation period (3 days instead of the usual 4 days for Western type virus) are certainly indicative of an Eastern type of encephalomyelitis virus.

From the foregoing, it would seem that the geographical limitation of the virus entities has now been broken down.

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THE "MEANING" OF SCIENCE

IT is well for every worker in science to sometimes attempt to set up for himself his concept of the broad field of his interest. I was stimulated to such inquiry by the recent statement of L. K. Frank that there is need for definition of the "meaning" of science.

Subjectively, and from the point of view of the intension of the term: Science is the data of the relations between things; between states; and between events: and of the relations between things, states and events.

Inherent in the term "things" are qualities. Inherent in the term "states" are modes and conditions of being. Inherent in the term "events" are those happenings which occupy a restricted portion of four-dimensional space-time.

There is no need to introduce the term "ordered" as a qualifier of relations since the sense of order is inherent in relation.

If by "meaning" one wishes to mean intent, pur-

pose, aim or object, then the definition slides toward objectivity and becomes:

Science is the accumulation of data on the relations between things; between states; and between events: and on relations between things, states and events.

If one wishes to introduce the pragmatic element, the definition becomes still more objective and is:

Science is the accumulation and application of data on the relations between things; between states; and between events: and on relations between things, states and events.

And finally if one wishes to be both pragmatic and humanistic the definition becomes completely subjective and is:

Science is the accumulation and application of data on the relations between things; between states; and between events: and on relations between things, states and events, for the benefit of mankind.

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SCIENTIFIC BOOKS

ALGEBRAIC THEORIES

Introduction to Algebraic Theories. By A. ADRIAN ALBERT. viii + 137 pp.; index. Chicago: The University of Chicago Press. 1941. $1.75.

DOUBTLESS the greatest hurdle which a student of mathematics in the United States has to take is the adjustment between undergraduate and graduate work. The amateur student has been replaced by the professional, drill in mechanical skills has been replaced by rigorous thinking, and the attitude that "the proof of this theorem is too hard for us so we shall assume it without proof" is gone forever.

The traditional courses of the senior and first graduate years are critical in the development of a mathematician. It is at this point that keen interest and ambition should be aroused in the student of ability. If uninspired teaching causes him to become bored, he will transfer his interest to another branch of learning. On the other hand, it is only just to a mediocre student to allow him to find out at this point that he will not make a satisfactory graduate student. A mere drill course will not satisfactorily test his abilities.

Elementary courses are best taught from texts, of which there are enough for every taste. Graduate courses are seldom taught from a single text, for the interests of the professor as well as the subject itself are in constant flux. But how are these transitional courses, the "senior" courses, to be handled? Frequently the instructor is not a specialist in the subject, and more frequently he has not the time to work up an adequate set of notes. A good text seems indicated.

But a satisfactory text for a senior course must be more than a rehash of a dozen earlier books. It must be an introduction to modern mathematics. The author must be acquainted with present-day research and he must be able to present his subject in a modern manner, for otherwise the course will not be an introduction to graduate mathematics. A text which is not modern in content and terminology just won't do.

The book under review successfully meets the necessary conditions set forth above. It is specifically designed to serve as an introduction to the author's "Modern Higher Algebra" (which is distinctly a book for graduate students) but can be used effectively by seniors and graduate students who merely wish to know something about matrices.

The book is in two quite distinct parts. The first 108 pages constitute an introduction to the theory of matrices. The usual topics are considered, rectangular matrices and elementary transformations, equivalence of matrices and of forms, linear spaces and polynomials with matric coefficients. The method of elementary transformations is used wherever possible, even in the proof that the determinant of a product of two square matrices is equal to the product of their determinants. The treatment of determinants is sketchy, for the student is assumed to know how to handle them, but it is lucid and in the modern manner, and should help in dispersing some of the fog emanating from the traditional treatment of determinants. Bilinear and quadratic forms are briefly treated without reference to projective geometry. Linear spaces rationalize the subject of similarity of matrices. Invariant factors and elementary divisors, without which matric theory is not matric theory, are treated in Chapter V.

Even though the author states that the book is written for juniors and seniors, it seems to be on the graduate-student side of the fence. It is a fairly solid and comprehensive treatise on the algebra of matrices with no by-lanes or diversions. There is very little motivation for the material, very little to enlighten a student regarding the significance of quadratic forms or similarity of matrices, for instance. There are many new problems in the book, and these will be welcomed by all who teach the subject, but they are mostly drill problems which help not at all in rationalizing the subject to an undergraduate. This means that the text must be administered by an understanding teacher. At various places in the text are to be found summaries of further results not treated in detail. Teachers hold

differing opinions regarding this as an effective method of teaching, but it should arouse the curiosity of the better students.

This policy of omitting proofs is carried to an extreme in the last twenty-four pages of the book. This last chapter is entitled "Fundamental Concepts," and one is tempted to believe that the author has designed it to serve as a preliminary chapter to his "Modern Higher Algebra." An abstract group is defined, and then one comes up against the statement but not the proof of the simple theorem that the order of a subgroup of a finite group is a divisor of the order of the group. This policy is continued throughout the chapter. After the definition of ring comes the statement, "We leave to the reader the explicit formulation of the definitions of subring and equivalence of rings. They may be found in the first chapter of the 'Modern Higher Algebra.'"

This last chapter, then, is an encyclopedic treatment of groups, rings, abstract fields, integral domains, ideals and residue classes, quadratic fields and their integers and the Gaussian field. It is interesting to a mature reader, and under the administration of an expert algebraist should be a quick road to knowledge. A non-specialist who attempts this chapter with a keen class may be in for a few bad moments.

This book is a distinct contribution to the mounting list of books devoted to modern algebra. It is modern in its viewpoint and correct in execution, and the student who has mastered it is on the graduate-student side of the hurdle, ready to pursue further work in abstract algebra.

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PHARMACY

History of Pharmacy. A Guide and a Survey. By EDWARD KREMERS and GEORGE URDANG. x + 466 p., 30 figures. Philadelphia: J. B. Lippincott Co., c1940. $5.00.

THIS history falls into 4 parts. The first deals with primitive pharmacy in Babylon and Assyria, Egypt, Greece and Rome, among the Arabs, and in Europe in the Middle Ages. The second describes the rise of professional pharmacy in Italy, France, Germany and England, and outlines the interrelations of medical theory and materia medica, giving a detailed account of its development. The international relations based on professional and industrial foundations arising between these countries are also discussed.

The third part gives a comprehensive account of the growth of pharmacy in the U. S. A. in the colonial, Revolutionary and national periods tracing the dependency of American pharmacy upon that of the several European parent countries. The progress of pharmacy in the U. S. A. was marked by the growth of local, state and national societies, and the enactment of local, state and federal laws. Education began in private schools followed by state-supported schools usually attached to universities. The establishment of legal qualifications administered by state examining boards led to supplemental correspondence and coaching schools.

Pharmaceutical literature in America took shape, after various state organizations had planned an American pharmacopoeia to replace those of London, Edinburgh, Dublin and Paris, widely used in the U. S. A., in the Massachusetts Pharmacopoeia (1808), followed by that of the New York Hospital (1818) and that of the U. S. A. (1820). The seventh edition (1862) was the first to be issued under the direct auspices of the American Pharmaceutical Association. Legal status was granted it by the Pure Food and Drug Act (1906). The eleventh revision (twelfth edition) appeared in 1936. This series of editions is in itself a historical record of the scientific advances not only in pharmacy but also in some aspects of biochemistry, immunology, endocrinology, and especially in the history of the growth of knowledge and standardizations of the vitamins. The chapter on the establishment of a literature also contains a record of textbooks, works of reference and journals.

Part IV records the discoveries, inventions and contributions to science by pharmacists in the fields of chemistry and biochemistry and to the wider field of literature. Annotated bibliographies are provided for each chapter. The glossary is unusually extensive, including much historical material which is supplemented by an elaborate chronology of dates of pharmaceutical and general scientific interest.

This book is a mine of biological and biochemical information related to pharmacy, as well as a detailed and inclusive history of pharmacy.

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REPORTS

THIRTIETH ANNUAL REPORT OF THE BROOKLYN BOTANIC GARDEN

IN the Annual Report of the Brooklyn Botanic Garden for the year 1940, which the director, Dr. C. Stuart Gager, has submitted for the thirtieth time since his appointment, he records not only the activities of the year, but also briefly calls attention to the progress which the Botanic Garden has made since it was established thirty years ago. It is noted that this progress has continued, with minor fluctuations, notwithstanding

the fact that the annual budget of the Botanic Garden has fallen from nearly $229,000 in 1930 to $195,000 in 1940 ($168,000 in 1934). This falling off of income has, of course, resulted in curtailing many of the activities, in the temporary suspension of some of them, and in some loss of personnel.

The total general attendance at the garden for the first thirty years of its existence was nearly 22,500,000, or almost three times the population of Greater New York, as shown by the 1940 census, and more than eight times the population of Brooklyn by the same census. During this period nearly 18,000 teachers have brought to the garden more than 1,000,000 pupils for instruction in all aspects of plant life and horticulture by members of the garden staff. In addition to this, there has been an attendance of adults and children of more than 1,000,000 at classes organized independently of the schools. The garden has also during its first three decades given talks, lectures and addresses at schools to audiences totaling nearly 2,550,000.

The director points out that in order to carry on this educational program and to maintain a large collection of plants indoors and under glass, in proper condition of health and culture and properly labelled, requires the presence of a scientific, as well as an educational staff, and the inclusion of a certain amount of scientific research in such subjects as plant disease, plant breeding and other aspects of plant life. During these thirty years the city has made a total appropriation in its tax budget of a little more than $2,200,000, which is about twenty-eight cents per inhabitant, or a trifle less than one cent per inhabitant per year. Contributions of private funds by the Board of Trustees of the Brooklyn Institute of Arts and Sciences, of which the garden is a department, have been nearly $1,715,000.

When the development of the plantations of the garden began, in 1911, part of the area was a dumping ground where refuse was daily burned. The remainder of the fifty acres comprising the grounds was almost wholly undeveloped. By a happy combination of botanists, horticulturists and a landscape architect, the garden has now become one of the most beautiful spots in Greater New York and is generally recognized as one of the most beautiful and educationally effective botanic gardens in the world.

The annual reports that have been issued since 1911 have shown that the garden is by no means a parochial institution serving merely Brooklyn and New York City, but that its scientific and educational publications and its work of public education are known throughout the world. The report records the steady growth of the library, open free daily to the public, and of the herbarium, open daily for consultation for those competent to use such collections. Special attention is called to the cooperation of the Botanic Garden in scientific and educational work with such organizations and institutions as the New York World's Fair; Works Progress Administration; Department of Parks; Board of Higher Education; Board of Education; the American Association of Botanical Gardens, which the Brooklyn Botanic Garden helped to found; the Brooklyn Civic Council; the Garden Club of America; New York Bird and Tree Club; five hospitals of Brooklyn, and numerous other organizations.

The increasingly serious financial situation throughout the world has made it conspicuously difficult to finance the scientific and educational activities of the garden and to maintain the plantations and grounds in a proper state of upkeep. The director calls special attention to the need of additional endowment. By a special system of economy during the past twenty years, involving the expenditure of only a portion of the income from its permanent funds, the Botanic Garden has added more than $150,000 to its endowment. In order to maintain its present activities and to meet the constantly increasing demand of the public and of various departments of the City of New York for service, an addition of $1,000,000 to the endowment fund is urgently needed.

The report of the director is followed by reports of the heads of the various departments of the garden and a detailed report of the Botanic Garden Budget for the year 1940.

SPECIAL ARTICLES

THE PREVENTION BY CHOLINE OF LIVER CIRRHOSIS IN RATS ON HIGH FAT, LOW PROTEIN DIETS[1]

IN connection with experiments on the feeding of wheat germ oil, it was reported[2] that diffuse nodular cirrhosis of the liver was produced in 7 rats which received large amounts of the oil (3 to 5 cc per day) for 243 days or longer. This regimen was notably high in fat and low in protein. In subsequent investigations by Blumberg and Grady,[3] this observation on the dietary production of cirrhosis was repeated and extended with wheat germ oil and also with corn oil; a description of the pathology of the cirrhosis and of the extensive fatty changes was presented.

The production of cirrhosis of the liver in 3 dogs on high fat diets has been reported by Chaikoff and

[1] This investigation was aided by a grant from William R. Warner and Co., Inc., New York City.

[2] H. Blumberg, *Pub. Health Rep.*, 55: 534, 1940.

[3] H. Blumberg and H. G. Grady, *Proc. Am. Soc. Biol. Chem.*, April, 1941; also, in press.

Connor.[4] By means of a deficient diet Rich and Hamilton[5] have produced cirrhosis in rabbits, and have reported its prevention by yeast. Spellberg and Keeton[6] observed cirrhosis apparently of dietary origin in 1 guinea pig and 1 rabbit in their experiments. According to a recent publication by Gyorgy and Goldblatt,[7] liver injury (necrosis, cirrhosis) was produced in rats on a diet containing 10 per cent. casein and 22 per cent. fat, with thiamin, riboflavin, pyridoxin and pantothenic acid supplied as members of the vitamin B complex.

In view of the fact that cirrhosis had been produced in our earlier experiments[2, 3] by diets high in fat and low in protein, we prepared more purified diets that were specifically low in choline, shown by Best, Hershey and Huntsman[8] to be a lipotropic factor. Diet A (55 per cent. fat) had the following composition: casein 10 per cent., sucrose 29, lard 51, corn oil 2, cod liver oil 2, and Salt Mixture No. 51 (McCollum) 6. This basal ration, deficient in the vitamin B complex, was supplemented with 10 mg of thiamin hydrochloride, 20 mg of riboflavin, 10 mg of pyridoxin hydrochloride and 20 mg of calcium pantothenate[9] per kilogram of diet. Diet C (70 per cent. fat) was exactly the same as Diet A, except that the lard content was increased 15 per cent. at the expense of the sucrose, so that the composition was as follows: casein 10 per cent., sucrose 14, lard 66, corn oil 2, cod liver oil 2, and Salt Mixture No. 51 (McCollum) 6. The 4 members of the vitamin B complex were added as in Diet A.

When rats of the McCollum piebald strain, half-grown to almost full-grown animals weighing 140 to 250 gm, were placed on these diets, cirrhosis of the liver developed on Diet A in approximately 125 to 150 days. On Diet C, cirrhosis was observed in animals which died or were sacrificed after approximately 100 to 140 days. The cirrhosis was frequently accompanied by severe ascites and hydrothorax, with occasional hydropericardium.

Microscopically, the cirrhotic livers showed scarring with alteration of the architectural pattern. In some cases there was considerable accompanying necrosis, with little in others. Variable amounts of fat were observed. Usually there were appreciable quantities of a yellow pigment, apparently similar to that previously observed to a slighter degree in the experiments with wheat germ oil.[3]

[4] I. L. Chaikoff and C. L. Connor, *Proc. Soc. Exp. Biol. and Med.*, 43: 638, 1940.
[5] A. R. Rich and J. D. Hamilton, *Bull. Johns Hopkins Hosp.*, 66: 185, 1940.
[6] M. A. Spellberg and R. W. Keeton, *Am. Jour. Med. Sci.*, 200: 688, 1940.
[7] P. Gyorgy and H. Goldblatt, *Proc. Soc. Exp. Biol. and Med.*, 46: 492, 1941.
[8] C. H. Best, J. M. Hershey and M. E. Huntsman, *Am. Jour. Physiol.*, 101: 7, 1932.
[9] Kindly supplied by Merck and Co., Inc., Rahway, N. J.

The addition of l-cystine, at a level of 25 mg per rat per day, did not retard the development of the cirrhosis. Preliminary results with d, l-methionine indicated a slowing of the cirrhotic process but not protection at a level of 25 mg per rat per day, although higher levels have not yet been tried. However, the cirrhosis was prevented by the addition of 1 per cent. choline hydrochloride (10 mg per gm of diet, or approximately 40 to 60 mg per rat per day). Normal livers were secured by the addition of the choline alone, in combination with methionine, or even with cystine, a substance which itself causes hepatic damage at toxic concentrations[10] and has been reported by Earle and Victor[11] to produce cirrhotic changes in rats when fed at the excessive levels of 5 per cent. or 10 per cent. of the diet.

It is interesting that Gyorgy and Goldblatt[7] in their experiments did not prevent liver injury by choline, although they found that "10 to 20 mg of choline daily reduced the incidence and severity of the liver injury but not to a great extent." They also reported an accentuation of cirrhosis of the liver by addition of cystine, and found that "the daily addition of from 10 to 20 mg of choline or of 1 gram of yeast, or better, of both, neutralized more or less completely the effect of cystine on the liver." Under our considerably different experimental conditions, the addition of choline was attended by protection against the hepatic cirrhosis itself. The possible relation of choline to other types of experimental cirrhosis and to the protective action of yeast, as reported by other workers, is under investigation.

Presumably, at least a large part of the beneficial effect of choline is brought about through its lipotropic activity, whereby it prevents the process of long-continued fatty infiltration which, according to Connor,[12] may lead to cirrhosis of the liver in diabetes and in chronic alcoholism in man. However, it may be that choline also exerts its protective action through some additional mechanism.

Cirrhosis of the liver has been produced in more than 30 rats fed the described high fat, low protein diets, whereas the development of cirrhosis has been prevented in a like number of animals by the addition of choline. Details of these experiments, together with observations on the effect of protein level and of yeast, will be reported elsewhere.

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[10] A. C. Curtis and L. H. Newburgh, *Arch. Int. Med.*, 39: 828, 1927.
[11] D. P. Earle, Jr., and J. Victor, *Jour. Exp. Med.*, 73: 161, 1941.
[12] C. L. Connor, *Am. Jour. Path.*, 14: 347, 1938.

THE METABOLISM OF β-NAPHTHYLAMINE BY RATS, RABBITS AND MONKEYS

VERY few pure chemical compounds have been reported to cause cancer in human beings. Considerable evidence indicates, however, that β-naphthylamine and benzidine cause cancer of the bladder in industrial workers exposed to these compounds.

This assumption is supported by the fact that cancer of the bladder has been produced experimentally in dogs[1] and in rabbits[2,3] by the oral administration of β-naphthylamine. Other experiments of this type have been unsuccessful, however.[4] Wiley[5] isolated the acid sulfate of 2-amino-1-hydroxy-naphthalene from the urine of dogs fed with β-naphthylamine. The presence of free β-naphthylamine and of a dihydroxy naphthylamine derivative in the urine of dogs similarly treated was suggested by other investigators[6,7] on the basis of color tests.

The metabolic fate of pure β-naphthylamine in rats, rabbits and monkeys has been studied in this laboratory. The compound was dissolved in olive oil and the animals were injected subcutaneously. The urines were collected at an acid pH and chloroform was employed as a preservative. After the addition of sodium hydrosulfite to prevent oxidation, the urine was extracted with ether first at an acid pH, and subsequently at a weakly alkaline reaction. The extracted urine was then hydrolyzed at pH 1 and re-extracted with ether as above. Neutral, phenolic, acidic, basic and phenolic-basic subfractions were obtained from the primary ether extracts.

The ultraviolet absorption spectra of the different fractions were studied with a hydrogen discharge tube as a source of light. With the exception of the fraction containing the acidic compounds, all the extracts of the urine of animals which had been injected with β-naphthylamine showed spectroscqpically a series of specific bands. These bands were not given by extracts of the urine of uninjected animals. Identical fractions from the urine of injected rats, rabbits and monkeys showed groups of bands in identical positions. This finding suggests that the three species excrete the same β-naphthylamine metabolites.

From the ethereal subfractions, three substances were isolated by means of high vacuum distillation, chromatographic adsorption analysis and recrystallization. The identities of these three substances were established by mixed melting points, elementary analysis and spectroscopic comparison with synthetic materials. The isolations were controlled by means of spectroscopic methods. The same β-naphthylamine metabolites were isolated in pure form from the urine of animals of the three different species which had been injected with β-naphthylamine, a fact which is in accord with the spectroscopic evidence.

The following compounds were isolated: (1) β-naphthylamine from the basic fraction, (2) N-acetyl-β-naphthylamine from the neutral fraction, (3) N-acetyl-2-amino-6-hydroxy-naphthalene from the phenolic fraction.

TABLE 1

ELEMENTARY ANALYSES[1] OF THE β-NAPHTHYLAMINE METABOLITES ISOLATED FROM URINE

		Theoretical Per cent.	Rats Per cent.	Rabbits Per cent.	Monkey Per cent.
β-naphthylamine	N	9.79	9.77	9.75	9.82
	C	83.86	83.91	83.79	83.80
$C_{10}H_9N$	H	6.34	6.37	6.40	6.39
	M.P.C.° (uncorr.)	113°	113°	113°	113°
N-acetyl-β-naphthylamine	N	7.56	7.65	7.55	7.58
	C	77.80	77.77	77.72	77.77
$C_{12}H_{11}NO$	H	5.99	6.00	6.08	6.04
	M.P.C.° (uncorr.)	132/33°	132°	132°	132°
N-acetyl-2-amino-6-hydroxy-naphthalene	N	6.97	[2]	7.04	6.92
	C	71.64		71.65	71.60
	H	5.47		5.54	5.56
$C_{12}H_{11}NO_2$	M.P.C.° (uncorr.)	223/24°	223°	223/24°	224°
Methyl ether of N-acetyl-2-amino-6-hydroxy-naphthalene	N	6.51	6.54		
	C	72.52	72.54		
	H	6.09	6.36		
	O CH_3 ..	14.42	14.4		
$C_{13}H_{13}NO_2$					

[1] Elementary analyses were made by the courtesy of Dr. A. Elek, Rockefeller Institute for Medical Research.
[2] Elementary analysis was made on the methyl ether.

In the fraction containing the phenolic bases from the non-hydrolyzed urine spectroscopic bands were seen in positions identical with those given by 2-amino-6-hydroxy-naphthalene,[8] a fact which suggested the presence of the free compound. After acid hydrolysis of the urine, the same bands could be seen in the phenolic-basic fraction. This suggests that either 2-amino-6-hydroxy-naphthalene or the acetyl derivative, or both, are excreted in part after conjugation as ethereal sulfates or glucuronates, forms which are not ether soluble.

From the urines of rats a very small amount of a naphthylamine derivative was isolated which has not yet been identified. Its properties suggest that it is a

[8] Obtained through the courtesy of Drs. W. Calcott and W. J. Balon, of the Jackson Laboratory, E. I. du Pont de Nemours, Wilmington, Delaware.

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dihydroxy aminonaphthalene. In the urine of rabbits and monkeys only traces of this compound were present.

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BACTERIAEMIA IN LAND-LOCKED SALMON (SALMO SEBAGO) IN MAINE

A HIGHLY fatal epizootic occurred among yearling salmon in a hatchery in Maine during July, 1940. The disease appeared to develop very suddenly, but it is possible that a dorsal-fin disorder which arose late in the winter was related to its development.

External lesions associated with the disease consisted of small, shallow, subcutaneous abscesses seldom exceeding a centimeter in diameter and two millimeters in depth. Perforation of even very small abscesses through a central pin-point opening was very common.

The pseudobranch of all sick and dead fish was intensely hemorrhagic and some fish showed hemorrhages in the gills. A few fish developed protrusion of the eyes with an attendant darkening in color.

Internally all fish showed hemorrhages dorsal to the swim-bladder along the post-cardinals. Some had inflammation of the lower intestine and around the anus. Abscesses and hemorrhages were clearly visible in the liver, spleen and kidneys of over half of the fish.

Microscopic examination of the blood, fluid from the orbit and all internal organs showed numerous bacteria typical for bacteriaemia. The pseudobranch was also heavily infected. From the cultures isolated two types of bacteria were found most frequently. In all cases typical strains of *Bacterium salmonicida* were obtained, while from several fish an additional type of bacterium was isolated.

All strains of *B. salmonicida* isolated on different occasions were identical and cross-agglutinated up to the titre of the homologous agglutinating sera.

The second type was motile and did not liquefy gelatine. Most of the strains of this bacterium were also identical in their biological and serological properties among themselves, but differed entirely from *B. salmonicida*.

Further studies are in progress.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A DESIGN FOR A SATURATED CALOMEL ELECTRODE[1]

THE electrode was designed with the purpose of avoiding disturbance of the interfaces and contamination of the saturated KCl. It is especially suitable for electrometric titrations of acid-base or oxidation-reduction reduction potentials where flushing of the connecting arm is essential. In most of the calomel cells, the flushing is obtained either by passing saturated KCl through the whole body of the cell or by a three-way stopcock in the connecting arm. In the first case, extreme care must be taken not to alter the potential of the cell through disturbance of the active surfaces, changes of temperature or changes in concentration of the solutions. The second method may lead to leaks of KCl in the solution to be measured or to a break in the continuity of the liquid column. An excellent design is that used by Clark in his oxidation-reduction studies. But its clever, though complicated, arrangement of stopcocks makes it difficult to manufacture except by a very expert glass blower, which accordingly raises its price. In the construction of the cell here described, two standard pyrex stopcocks are used: one (A), a straight, two-way 8 mm O.D. with 2 mm bore in the plug; and one (B), a three-way capillary 7 mm O.D. and 1 mm bore. In the latter the plug is changed for a two-way right angle connection.

The cell is entirely made of pyrex glass. Electrical connection is made by means of a thin platinum wire through a heavy pyrex seal. The platinum wire beyond the seal dips into mercury placed in the bottom of the small lower bulb. This lower bulb has a small hole through which a wire is introduced as an electrical lead to the potentiometer (not represented in the diagram). Once this lead wire is in place a permanent connection may be made by fixing it with a plastic cement, which is made also to close the small hole of the bulb. The lower bulb is not completely filled with mercury, *i.e.*, the mercury does not touch the seal. This avoids any contamination of the purified mercury inside the electrode through a possible defect in the seal around the platinum wire.

The cell is filled completely through stopcock A with stopcock B open to the connecting arm. Once the cell is filled stopcock A is permanently closed. Contamination of the solution with stopcock grease may be

[1] From the Department of Physiology, Tufts College Medical School.

avoided by filling the cell through a thin glass tube introduced beyond the stopcock, which for this purpose was chosen to be of large bore. Mercury is added until its surface reaches the middle of bulb C. At this point the diameter of the bulb is the same as the body of the cell allowing a good surface of contact between mercury and calomel. The bulb is limited by two constrictions. The lower one, usually found in electrodes of this type, prevents the solutions from wetting the platinum wire. The upper constriction is filled with KCl crystals by filling the cell with slightly supersaturated KCl solution. The crystals settle and pack together in a short time. This minimizes the disturbance of the active interfaces when the electrode is moved.

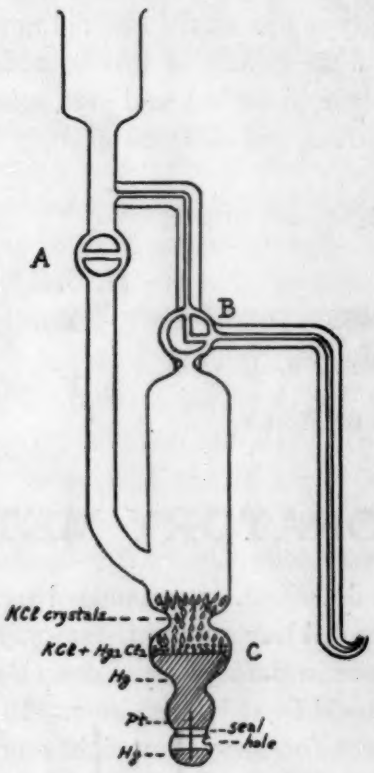

FIG. 1

Flushing the connecting arm with saturated KCl from the reservoir is done by turning the stopcock B to the position indicated in the diagram. During determinations the stopcock B is turned a quarter turn from the position in the diagram, providing a continuous column of conducting liquid with little resistance. If the cell has been subjected to changes of temperature, the change in the internal pressure can be eliminated by momentarily opening the cell towards the connecting arm after previously flushing the latter.

The end of the connecting arm may be shaped in any form desired such as the enlarged bulb type designed by Clark to obtain reproducible liquid junctions.

The cell as described is very rugged and gives very constant potentials.

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A CONVENIENT METHOD OF LABELING BOTTLES

I AM interested in the note furnished by Messrs. Gurchot and Finnegan[1] regarding the labeling of bottles. I have used the same method and found it satisfactory. Also I have found that one-inch wide transparent cellulose tape is excellent for protecting the labels on microscope slides. Formerly I used clear shellac to protect the label, but I find that cellulose tape is better since it gives enduring protection.

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CENTRE COLLEGE

HOW TO REMOVE THE PLUNGERS OF "FROZEN" GLASS SYRINGES

IN the hands of the inexperienced or of the absent-minded, a syringe that is used to draw blood often becomes "frozen." The plungers of such syringes can be removed by boiling them for fifteen or twenty minutes in glycerine. The syringe should be completely submerged in a container with walls high enough to prevent boiling over. The job should be done in a hood and the low flame watched carefully.

While the glycerine is boiling, the syringe should be removed with tongs and the plunger pulled with a towel or a pair of heavy forceps. If the plunger does not come out the syringe may be boiled again and a second or third trial made. It usually comes out the first time.

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